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Life Expectancy and Health Care Expenditures:

A New Calculation for

Germany Using the Costs of Dying

by

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Abstract

Some people believe that the impact of population ageing on future health care expenditures will be quite moderate due to the high costs of dying. If not age per se but proximity to death determines the bulk of expenditures, a shift in the mortality risk to higher ages will not affect lifetime health care expenditures as death occurs only once in every life. We attempt to take this effect into account when we calculate the demographic impact on health care expenditures in Germany. From a Swiss data set we derive age-expenditure profiles for both genders, separately for persons in their last four years of life and for survivors, which we apply to the projections of the age structure and mortality rates for the German population between 2002 and 2050 as published by the Statistische Bundesamt.

We calculate that at constant prices per-capita health expenditures of Social Health Insurance would rise from € 2,596 in 2002 to between € 2,959 and € 3,102 in 2050 when only the age structure of the population changes and everything else remains constant at the present level, and to € 5,485 with a technology-driven exogenous cost increase of one per cent per annum. A "naïve" projection based only on the age distribution of health care expenditures, but not distinguishing between survivors and decedents, yields values of € 3,217 and € 5,688 for 2050, respectively. Thus, the error of excluding the "costs of dying" effect is small compared with the error of underestimating the financial consequences of expanding medical technology.

1 Introduction

Financing the modern welfare state in the future is commonly believed to be one of the most urging problems in today’s politics. Presently, German workers pay 42 per cent of their payroll for social insurance, a high tax wedge that is detrimental for employment. Therefore, politicians are desperately searching for ways to prevent or at least alleviate a further dramatic increase in the costs of social insurance over the next 30 to 40 years, e.g. by introducing a „sustainability factor“ in the calculation of retirement benefits.

A big uncertainty is connected with the development of the expenditures of Social Health Insurance (henceforth: SHI) because its benefits are predominately in kind rather than cash, and the nature of the respective product „health care“ will change through technical progress in medicine as the structure of demand will change through a rising life expectancy. There have been numerous attempts to forecast the development of the average payroll contribution rate of German sickness funds. The spread of rates is rather wide. In his survey of forecasts, which have been published since 1995, Postler (2003, p. 23) reports on contribution rates for the year 2050 of between 16.5 and 39.5 per cent, where the lower values refer to simulations of the effect of demographic change alone, ignoring any expenditure growth due to progress in medical technology.[1]

The uncertainty expressed in this wide spread, critical for health and social policy plans, has led to a fierce controversy on the need of a fundamental reform of the system of health care financing in the long run. Even the rather timid attempts to introduce more self-responsibility of patients, e.g. through a physician service fee of 10 Euro per quarter, are attacked by trade unions and social democratic leftists to be the beginning of the dismantling of the welfare state. All the more, members of these circles openly deny that it may become necessary within the next decades to limit the set of basic benefits in SHI and in turn to widen the scope of supplementary private insurance. Politicians, for the same reason, are reluctant to introduce further legislation that would restrict the benefit package of SHI in the long run as such programs, interpreted as welfare state retrenchment, may risk the loss of many votes.

[1] The current average contribution rate in the German SHI is 14.2 per cent.

This reluctance runs the danger that inevitable reforms will later hit the citizens unexpectedly and might place a much heavier burden on them than a timely long-run policy. In particular, the build-up of private, capital-funded supplementary insurance requires a time lead of several decades.[2] For these reasons, it is important to reduce those controversies, which are derived from uncertainty of the future development.

A closer inspection differentiates three factors affecting future contribution rates,

1. the impact of population ageing on the incomes, on which sickness fund contributions are levied: the latter shrinks when the share of workers in total population falls;
2. the impact of ageing, in particular of the growth in life expectancy on per-capita expenditures;
3. the impact of medical progress on per-capita expenditures.

The first effect would be eliminated by a transition from income-related contributions to per-capita premiums since pensioners would then have to pay the same rates as workers. The sign of the third effect is hardly controversial since there is by now a wide-spread agreement that medical progress predominantly consists of new products and procedures with both higher quality and costs. Only the size of this effect is still somewhat unclear. Breyer and Ulrich (2000) estimated it from the coefficient of time in a regression of per-capita expenditures on age structure and income, finding a growth rate of one per cent per annum.

Hence, it is the second effect that is at the center of the controversy on the future development of health care expenditures. There are at least three hypotheses on the impact of an increase in life expectancy on health care costs with constant medical technology:

a) The status-quo hypothesis assumes that age-specific per-capita expenditures depend only on the state of medical technology and remain stable when the latter is controlled for. The impact of life expectancy can be calculated by applying present age-expenditure profiles on the future age distribution of the population (see, e.g., PROGNOS 1998).

[2] See, e.g., Breyer (2000).

b) The medicalization hypothesis (Krämer 1993, 1996) is based on the observed multimorbidity of many elderly patients and states that new possibilities of treating a specific type of illness (e.g. heart disease) prolong the patient's life without perfectly restoring his/her health so that shortly after another disease sets in (e.g. cancer), which requires additional treatment. According to this hypothesis, the main effect of technical progress in medicine is to prolong the life of those patients who are so sick that they would otherwise die, implying that average health status of the population deteriorates over time. This explains Krämer's dictum (1993, p. 31) that "we spend the largest part of the additional years in the sickbed".

c) The compression hypothesis is based on the conjecture that the observed difference in the health care expenditures between young and old persons in cross-sectional data are not primarily due to calendar age, but are caused by the differences of time to death (e.g. Fuchs 1984): in higher age groups, a larger share of persons is in their last years of life, in which – in a futile attempt to prevent death – a high amount of money is spent for medical treatment. In such a situation, an increase in life expectancy – caused by medical progress or simply by a healthier life style – lowers age-specific death rates and thus fewer persons are in their last years of life in each age group. In other words, the years with high expenditures towards the end of life are compressed and constitute a smaller share of the total lifespan.

While the medicalization hypothesis claims that a naïve simulation of future health expenditures on the basis of present age-expenditure profiles underestimates the true growth in health expenditures (even with constant medical technology), the *weak* compression hypothesis suggests the exact opposite. The *strong* compression hypothesis, moreover, claims that an increase in life expectancy – through a drop in the total mortality rate – will even lower per-capita health care expenditures.

There is hardly any empirical evidence in favor of the medicalization hypothesis. On the contrary, Dinkel (1999), exploring data from the German microcensus, finds that younger cohorts (birth years 1919 and 1913) not only experienced more life years beyond age 60 than older ones (birth year 1907) but an even larger increase of healthy life years. On the other hand, the compression hypothesis stands on a firm empirical basis: the increase of treatment costs in the years before death has been convincingly documented in numerous studies with data from various countries (e.g.

Lubitz and Riley 1993, Zweifel et al. 1996, 1999, Stearns and Norton 2004, Seshamani and Gray 2004a, 2004b).

An additional effect, further strengthening the compression hypothesis, is the reluctance of physicians to treat very old terminally ill patients as aggressively as they treat younger patients with similar symptoms, a behavior commonly interpreted as „age-based rationing“. To the extent that this lets costs of dying decrease with age beyond a certain threshold, it accentuates the overestimation of future expenditures in status-quo predictions. The empirical evidence on the decline of the cost of dying at a very high age is unambiguous. Although Zweifel et al. (1996, 1999) found no significant age impact on health care expenditures among deceased persons in Switzerland, they report a decline of the costs of dying among the over 65-years-old decedents, a finding that was confirmed by Felder et al. (2000) and Schellhorn et al. (2000). Lubitz et al. (1995) showed that Medicare expenditures in the last two years of life for 70-years-old decedents were around 50 per cent higher than for persons who died at age 90. Similarly, Busse et al. (2000) found in a German sample that the number of hospital days in the last year of life peaked at the age group 55 to 64 and declined steadily with rising age of dying thereafter.

Even if it is no longer questionable that the status-quo hypothesis overestimates the impact of demographic ageing on per-capita health care expenditures it is still interesting to assess the extent of the error. A first, rather crude attempt by Breyer (1999), using hospital days of surviving and deceased patients, estimated that the true ageing-related increase in total expenditures will amount to only 40 per cent of the one calculated with a status-quo projection.

Now, a new data set from a Swiss sickness fund allows a much more precise assessment of the error in a naïve forecast. This data set contains the annual health care expenditures of over 91,000 persons of whom approximately four per cent died within a time span of three and a half years. Using a regression analysis, we estimate age-expenditure profiles for men and women, each separated by survival status (survivors versus decedents). Applying these expenditure profiles to the age structure of the German population in the coming decades as predicted by the Statistische Bundesamt,[3] taking the estimated age-specific death rates into account allows an as-

[3] Statistisches Bundesamt (2003), 10. koordinierte Bevölkerungsvorausberechnung, Wiesbaden.

sessment of the purely ageing-related increase in health care expenditures. By contrasting this „sophisticated“ projection with a ”naïve“ status-quo prediction, it will be possible to assess the extent of the error more precisely than it was possible with previous data sets.

In the following we shall compare three different scenarios. In the first scenario, age-specific average health expenditures of the year 2002 will be directly applied to the age composition expected for future decades. In the second scenario, we distinguish explicitly between persons in their last four years of life and those who survive longer than that. In the third scenario, we take the compression hypothesis literally by adjusting the age-specific expenditures rightward by the difference in age-specific remaining life expectancies. For example, if the remaining life expectancy of a 65-year old will increase by 4 years until 2050, we shall assume that a 65-year old in 2050 will only spend as much as a 61-year old today.

To avoid possible misinterpretations of our study, we emphasize that we do not attempt to *forecast* future health care expenditures. Instead we try to calculate a contrafactual, namely what the expenditures in 2002 would have been if the demographic composition corresponded to the predictions for certain dates in the first half of the 21st century.[4]

The remainder of this paper is organized as follows. In Section 2 we describe the data and explain our methodology, in Section 3 we present the results, while Section 4 concludes.

2 Data and Methods

A Swiss sickness fund made 1999 claims data of 91,327 persons available to us. Of these persons, four per cent died between January 1st, 2000 and June 30th, 2003, i.e. 96 per cent survived the year 1999 by at least 42 months. The data set allowed us to estimate the impact of both age and time to death on health care expenditures for both survivors and decedents. To account for the fact that in any given year there are persons with zero expenditures, we performed a two-stage estimation of individual health care expenditures (H_i) with the following result:

[4] We are not interested in the effect of demographic change on total health expenditures, which is at the center of the study by Schulz et al. (2004).

$$\Pr\left(\mathrm{H_i}{>}0\right) = 0.786 - 0.001 \cdot A_i + 0,2 \cdot \frac{A_i^2}{1000} - 1.16 \cdot M_i + 0.014 \cdot \left(A_i \cdot M_i\right) \\ +0.971 \cdot D_i - 0.012 \cdot \left(D_i \cdot A_i\right) - 0.008 \cdot TtD_i \ , \tag{1}$$

$$H_i \middle| H_i > 0 = 17.234 - 189 \cdot A_i + 2.256 \cdot A_i^2 + 1.520 \cdot M_i - 29,7 \cdot \left(A_i \cdot M_i\right) \\ +8.488 \cdot D_i - 75,8 \cdot \left(D_i \cdot A_i\right) - 239 \cdot TtD_i , \tag{2}$$

where A denotes age, M is a dummy variable for males, D is a dummy variable for decedents and TtD ("time to death") measures the time span in months between December 31st, 1999 and the date of death. For people still living at the end of the observation period we set TtD = 43..[5] Both the gender dummy and the dummy for decedents are interacted with age to account for differences in the division of health expenditures both between genders and by survival status. Expected health care expenditures are calculated according to $H_i = \Pr\left(H_i > 0\right) \cdot H_i \middle| H_i > 0$ and are measured in Swiss Francs (SFr, 0.67 € at the current exchange rate).

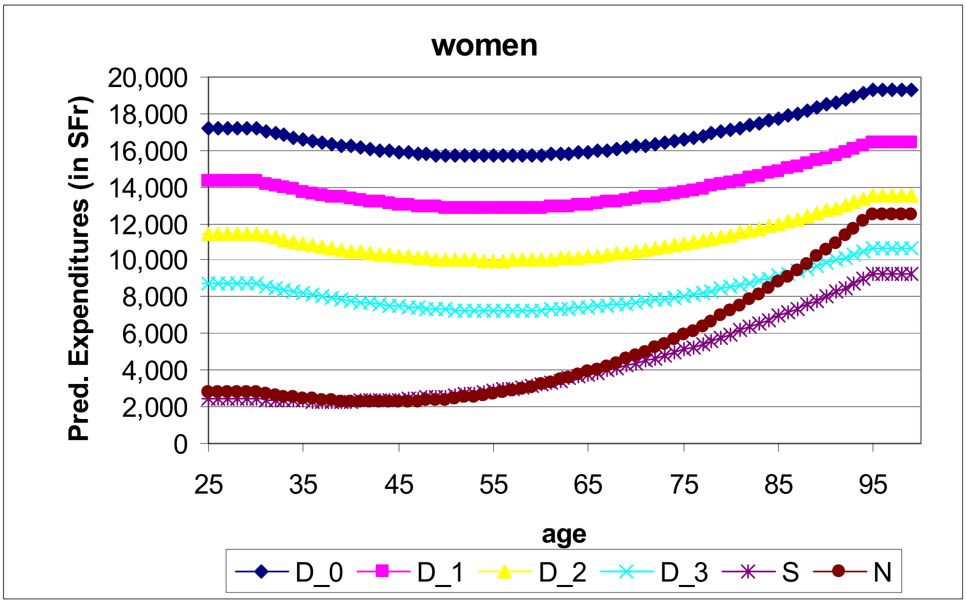
The estimates are limited to the age interval (30, 95). For persons below 30 and above 95 years of age we set health care expenditures equal to the values at the boundaries of the interval. When we insert the values 6, 18, 30 and 42 for TtD in equations (1) and (2), we obtain estimates for health care expenditures in the last, last but one year of life and so forth. We get predicted annual expenditures of survivors when we set D = 0 and TtD = 43. Figure 1 shows the per-capita health expenditures as a function of age for the five groups defined above, separately for men and women. The rather flat U-shaped curves of all groups, in particular decedents, is due to the common estimation with a quadratic specification of the age variable[6]. If we only look at health expenditures in the last year of life, we will get the well-known concave shape with decreasing expenditures beyond age 65. The sixth curve in Figure 1 represents predicted health expenditures as a function of age if the information on the survival status is ignored. It is derived from the following regression equations:

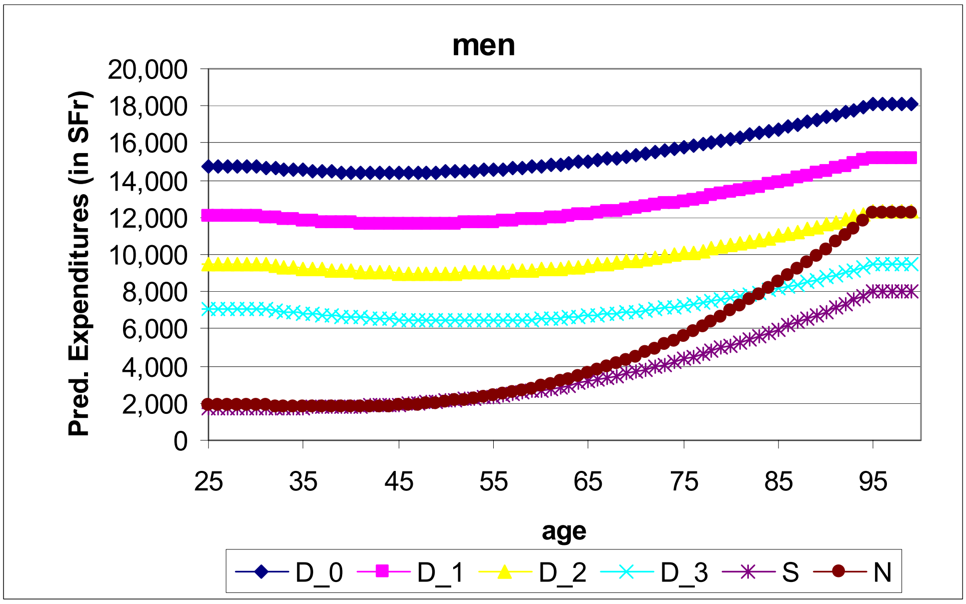
$$\Pr\left(H_i{>}0\right) = 0.485 - 0.0025 \cdot A_i + 0.18 \cdot \frac{A_i^2}{1000} - 1.17 \cdot M_i + 0.014 \cdot \left(A_i \cdot M_i\right) \ , \tag{3}$$

$$H_i \middle| H_i > 0 = 11.106 - 382 \cdot A_i + 4.015 \cdot A_i^2 + 978 \cdot M_i - 14,94 \cdot \left(A_i \cdot M_i\right). \tag{4}$$

[5] Alternatively, we used dummy variables for survivors and persons in their last year, last-but one year etc., which did not change the results. For the estimation, the metric approach is easier to use.

Figure 1: Predicted expenditures (in SFr) of women and men: persons in their last year (D_0), last year but one (D_1), last year but two- (D_2), last year but three (D_3) and survivors (S) and in the "naïve" scenario (N).

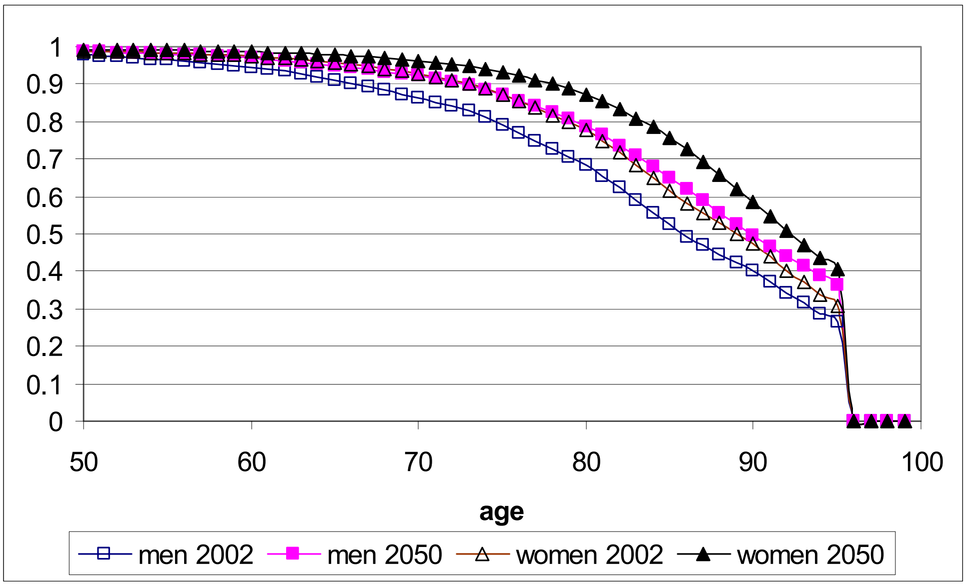




The graph of this "naïve" estimate of health care expenditures is steeper above age 50 than the curves for the individual groups because of the effect of rising mortality with age.

[6] For details of the regression's specification see Zweifel et al. (2004).

Figure 2: Age-specific four-year survival rates for women and men, 2002 and 2050



The second data source is derived from the population forecasts of the German Statistical Office for the time span until 2050. From the numbers of persons at the respective age in consecutive years (2002, 2010 - 2050), we can calculate the age-specific probabilities to die in the present, in the next year, in two and in three years time ($q(A|A), q(A+1|A), g(A+2|A), q(A+3|A)$). Hence, the probability to survive for at least four years is $p(A+3|A) = 1 - \sum_{i=A}^{A+3} q(i|A)$.

Figure 2, comparing the four-year survival rates in the years 2002 and 2050 reveals a rectangularization of the age-specific survival rates due to the increase in life expectancy.

According to the compression hypothesis, the increase in life expectancy will lead to a flatter age-expenditure profile. We take this effect into account in a separate scenario in which we adjust the age of the surviving individuals downward by the increase in life expectancy:

$$\tilde{A}_t = A_t - \left(LE_{A,t} - LE_{A,2002}\right) \quad . \tag{5}$$

The procedure can be illustrated for a 60-year old man whose remaining life expectancy is predicted to increase until 2050 from 19.5. to 23.7 years. Following equation (5), the 60-year old man will be assigned the age "56" in the 2050 demographic structure and thus will be imputed lower health expenditures than a 60-year old man in 2002.

3 Results

We combined the two data sets described above, age-expenditure profiles for survivors and decedents from Switzerland and the population forecast for Germany, to estimate the purely demographic impact on per-capita health expenditures until 2050 when everything else, in particular technology and prices, is held constant. We distinguished the "*q*-model", which takes into account the costs of dying and the expenditures in the last four years of life, from the "*n*-model", which contains a naïve projection of expenditures on the basis of the age and gender structure of the population alone.

As a first step, we calibrated both models to Germany's total health expenditures in 2002, which amounted to € 186.41 billions. Calibration proceeded as follows: using equations (1) and (2) or, alternatively, equations (3) and (4), together with the numbers of people in the age and sex classes of the German population in 2002, we calculated the German health care bill in Swiss franks. This figure, then, was adjusted to the actual bill in € and divided by the total German population in 2002. Thus, both models are able to produce per-capita health expenditures of € 236 per month, the figure quoted by the Statistische Bundesamt for that year. However, we chose a narrower definition of health expenditures, not comprising private health insurance payments and out-of-pocket expenses, thus arriving at monthly expenditures of € 216.66 per capita.

The projection of health care expenditures is derived from the forecast of age structure and mortality in the scenario V5 of the Statistische Bundesamt (medium values of immigration and life expectancy). We focus on per-capita expenditures which are the relevant measure from a financing point of view. In calculating the *q*-model, we further distinguish *q1* from *q2*, in which in addition to the separation between survivors and decedents, we adjust the age of survivors downward according to equation (5).

3.1 Only age structure changes

Table 1 shows the development of per-capita expenditures until 2050, both for the *n*- and the *q*-model, assuming that everything but the age structure remains constant at year 2002 levels. According to the status-quo projection, expenditures would increase by 23.9 per cent to € 3,217 per annum. If costs in the last years of life are taken into account, this growth is diminished to 19.5 per cent, a level of € 3,102 per annum in 2050. Taking the ratio of the two growth rates (.195 / .239 = .815), we see that, taking the naïve projection as our point of reference, the explicit distinction between survivors and decedents in the *q1*-model lowers the estimate of the expenditure growth by 18.5 per cent or not quite one-fifth. In the *q2*-model, per-capita expenditures rise only by 14 per cent to € 2,959. In this case, the error of the *n*-model amounts to about 40 per cent.

Table 1: Age-specific expenditures of 2002 and demographic change until 2050 with and without costs of dying

year	*n*-model		*q*-models				Error of the *n*-model in per cent	
			q1		*q2*		*q*1	*q*2
	in €	2002=100	in €	2002=100	in €	2002=100		
2002	2,596	100.00	2,596	100.00	2,596	100.00	0	0
2010	2,691	103.66	2,674	103.00	2,642	101.77	18.0	51.7
2020	2,827	108.91	2,788	107.38	2,745	105.73	17.2	35.7
2030	2,961	114.05	2,894	111.45	2,798	107.78	18.5	44.7
2040	3,094	119.19	3,007	115.83	2,885	111.11	17.6	42.1
2050	3,217	123.92	3,102	119.49	2,959	113.96	18.5	41.6

In the two alternative population scenarios with low and high increase in life expectancy (V2 and V8, respectively), the growth in expenditures is corrected by 13.9 and 22.9 per cent when costs of dying are taken into account. When in addition the age-expenditure profile of survivors is adjusted for changes in life expectancy, we get error rates of 38.9 and 44.3 per cent, respectively.

If we assume a low immigration rate and a medium rise in life expectancy (scenario V4), per capita expenditure growth equals 27.3 per cent in the *n*-model 22.7. per cent in the *q1*-model and 17 per cent in the *q2*-model, indicating that the immigration of on average younger persons will reduce the growth of Germany's health care bill.

If the purely demographic expenditure growth by 19.5 per cent in 48 years is transformed into a constant annual growth rate over the time span 2002 - 2050, this rate amounts to .37 per cent in the scenario V5. In the extreme scenarios of the change of life expectancy the annual demographic growth rate is .36 and .38 per cent.

From these results, the following preliminary conclusions on the development of per-capita health expenditures with constant medical technology arise:

1. The purely demographic growth of per-capita health expenditures is not really dramatic.
2. The (strong) compression hypothesis, which claims that ageing as such will have *no positive effect* on per-capita health care expenditures since individual expenditures are primarily a function of proximity to death, is not confirmed either. The explicit distinction between expenditures of survivors and those of decedents reduces the growth forecast only by one-fifth, and even assuming a rightward shift of the age-expenditure profile for survivors by the increase in life expectancy reduces it by only another fifth.

3.2 Age structure and medical technology changes

To forecast the total development of health care expenditures (at constant prices), it is necessary to account for the growth factor "technological change" in medicine, which has increased per-capita expenditures by one per cent per annum in the period 1970 to 1995, holding income and age structure constant (Breyer and Ulrich

2000).[7] Factoring this growth rate into our models above, we will obtain the values in Table 2. The implicit assumption underlying this calculation is that there is no growth in real income because productivity gain is entirely made up of increased product quality.[8] Moreover, technical progress in medicine lets quality of medical care grow at a faster rate so that age-specific health expenditures rise by one per cent per year. Observe that under these assumptions per-capita expenditures would more than double in real terms until 2050, where the error of the *n*-model now amounts to only a small share (between six and fifteen per cent) of the total increase in expenditures. As an annual rate, per-capita expenditures will grow by 1.57 per cent between 2002 and 2050.

Table 2: Age-specific expenditures of 2002, demographic change until 2050 and medical progress (1 per cent growth per annum)

year	*n*-model		*q*-models				Error of the n-model in per cent	
			*q*1		*q*2		*q*1	*q*2
	in €	2002=100	in €	2002=100	in €	2002=100		
2002	2,596	100.00	2,596	100.00	2,596	100.00	0	0
2010	2,946	113.43	2,927	112.72	2,892	111.38	5.3	15.3
2020	3,473	133.79	3,426	131.96	3,373	129.91	5.4	11.4
2030	4,094	157.71	4,002	153.84	3,870	149.04	6.7	15.0
2040	4,829	186.00	4,694	180.81	4,503	173.42	6.0	14.6
2050	5,688	219.08	5,485	211.25	5,232	201.51	6.6	14.7

[7] This figure is much smaller than the four per cent calculated by Fuchs (1999a, 1999b) for the excess of real growth of per-capita health care expenditures of the elderly over the growth rate of GDP.
[8] Thus our results are not directly comparable with forecasts of health expenditures in scenarios where real income rises over time, such as Breyer et al. (2004), p.149.

4 Concluding Remarks

In the introduction we presented three alternative hypotheses referring to the impact of the increase in life expectancy on per-capita expenditures in SHI in Germany and countries with similar demographic challenges. Taking Swiss expenditure data as a basis, the (weak) compression hypothesis gets the strongest confirmation of these hypotheses: Explicitly accounting for costs in the last years of life leads to a downward correction of the demographic impact on per-capita expenditures, as compared to a calculation on the basis of crude age-specific health expenditures. However, the error of the naïve calculation is much smaller than commonly asserted and amounts to slightly less than one-fifth of the predicted demographic effect on expenditures. Moreover, the impact of medical progress on health care expenditures is much larger than the impact of ageing so that taking this factor into account diminishes the relative importance of the error in the calculation of the demographic effect even further. Even when it is assumed that the whole age-expenditure profile shifts to the right by the increase in remaining life expectancy, a considerable part (60 per cent) of the estimated demographic increase in age-specific health expenditures until 2050 remains valid.

For a number of reasons, the results presented here must be interpreted with caution. First, age-expenditure profiles of Switzerland do not have to be representative for Germany. In fact, the age-expenditure curve found in German data is somewhat flatter than the respective curve in the data used here.[9] Thus, we have probably overestimated the ”true“ demographic effect on expenditures in Germany so that our conclusion that the development of medical technology has the larger potential for expenditure growth than demographic change is corroborated.

Finally, it must be emphasized that our analysis was restricted to the expenditure side of financing SHI, thus ignoring the impact of population ageing on the income basis, on which sickness fund contributions are levied. But given the tremendous increase in expenditures over the next decades, the transition to per-capita

[9] Publications of the Bundesversicherungsamt on the RSA (Risk Adjustment System) 2002; ”Analytical“ Values (written communication).

premiums may be a necessary step to at least partially uncouple health care financing from demography.

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